IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	:	10/695,484
Applicant	:	Dennis D. McCrady
Filed	:	October 29, 2003
TC/A.U.	:	2611
Examiner	:	Corrielus, J.
Confirmation No.	:	5217
Docket No.	:	0918.0244C
Customer No.	:	27896
Title	:	Methods and Apparatus for Transmitting Non-Contiguous Spread Spectrum Signals for Communications and Navigation

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION UNDER 37 C.F.R. § 1.131

Sir:

DENNIS McCRADY declares that:

1. I am the inventor of the invention entitled "Method and Apparatus for Transmitting Non-Contiguous Spread Spectrum Signals for Communications and Navigation," disclosed and claimed in the above-identified patent application.

2. Prior to October 24, 2002, I had conceived and reduced to practice the system and method for generating a signal for transmission in non-contiguous frequency bands recited in claims 1-32 of the above-identified patent application.

3. Evidence of conception and reduction to practice of the invention prior to October 24, 2002 is provided in the form of the attached written invention disclosure. The written invention disclosure was prepared before October 24, 2002. In particular, the relevant pages of the written invention disclosure show that the claimed system was made, and the claimed methodology was developed, prior to October 24, 2002.

4. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these

statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 4/26/07 By: Dennis McCrady
Dennis McCrady

RECORD OF INVENTION

ITT DEFENSE & ELECTRONICS
PATENT DEPARTMENT
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FILE NO.DTC- D-ACO-E078

TO: PATENT COUNSEL'S OFFICE FROM Dennis McCrady, ITT A/CD

SUBJECT Non-Contiguous Spread Spectrum Communications and Ranging DATE

SECTION A – INVENTORS NAME, SSN, COUNTRY OF CITIZENSHIP AND ADDRESS

NAME (First)	(Middle)	(Last)	SOCIAL SECURITY NUMBER	CITIZEN OF
Dennis D. McCrady				USA
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NAME (First)	(Middle)	(Last)	SOCIAL SECURITY NUMBER	CITIZEN OF
ADDRESS (Street No and Name)	(City)	(Country)	ZIP CODE	
NAME (First)	(Middle)	(Last)	SOCIAL SECURITY NUMBER	CITIZEN OF
ADDRESS (Street No and Name)	(City)	(Country)	ZIP CODE	

SECTION B – CONCEPTION INFORMATION

WHEN AND WHERE DID YOU FIRST CONCEIVE THIS INVENTION?
ON: AT: ITT Aerospace/Communications Division, Clifton, NJ

(A) DATE OF FIRST SKETCH OR DRAWING		(B) WHERE CAN THIS BE FOUND? Dennis McCrady file folder for this patent
(A) DATE OF FIRST WRITTEN DESCRIPTION		(B) WHERE CAN THIS BE FOUND? This invention disclosure
FIRST DISCLOSURE	TYPE NAMES OF PERSONS TO WHOM DISCLOSED John Bertrand, ITT A/CD	DATE OF FIRST DISCLOSURE
TO OTHERS	NA	

SECTION C – CONSTRUCTION AND TEST OF WORKING MODEL

FIRST WORKING MODEL OR INSTALLATION
DATE: None LOCATION: NA

FIRST TEST OR OPERATION OF THE INVENTION
DATE: None LOCATION: NA

SECTION D – USE, SALE AND PUBLICATION INFORMATION

(i) DATE OF FIRST PUBLIC USE (Past or Prospective Use)	(i) LOCATION OF SUCH USE NavSys Inc., Colorado Springs, CO; PLT STO for Stricom/Cecom
(ii) DATE OF FIRST SALE OR OFFER OF SALE None	(i) TO WHOM NA
(iii) DATE OF FIRST PUBLICATION None	(iii) NAME AND PLACE OF PUBLICATION NA

SECTION E – PROPERTY FORMATION

WAS THIS INVENTION MADE UNDER A CONTRACT? (GOVERNMENT OR OTHER) ☐ YES ☒ NO

IF SO, WHAT IS THE CONTRACT NUMBER? NA

IS THIS INVENTION CLASSIFIED BY THE GOVERNMENT? ☐ YES ☒ NO

WHAT IS ITS CLASSIFICATION ☐ TOP SECRET ☐ SECRET ☐ CONFIDENTIAL - **UNCLASSIFIED**

SECTION F - FUNDING

a) % ITT Funding (IR&D / B&P) 100%

b) % 3rd party Funding (Government or other) NA%

c) Identify ITT R&D case numbers 01632903

d) and local unit engineering project number(s) NA

SECTION G - INVENTION DISCLOSURE

Disclosure should be by written description or by sketches and each sheet should be signed by the inventor(s) and two competent witnesses. (A competent witness is a person who (1) understands the technical aspects of an invention, and (2)is not a joint inventor.) Following the outline below, briefly describe the invention on a suitably witnessed technical paper and attach it to this form.

1. TITLE OF INVENTION
2. INVENTOR(S)
3. DESCRIPTION OF THE OPERATION OF OTHER SIMILAR DEVICES
4. DESCRIPTION OF SOME OF THE SHORTCOMMINGS OF THE ABOVE MENTIONED DEVICES
5. GENERAL DESCRIPTION OF HOW THIS INVENTION OVERCOMES THE AFFORMENTIONED DIFFICULTIES.
6. SPECIFIC DESCRIPTION OF THE OPERATION OF THIS INVENTION MENTIONING ALL OF THE COMPONENTS AND FUNCTIONS THEREOF.
7. LIST ALL POSSIBLE APPLICATIONS.

DUTY OF DISCLOSURE

Inventors have a duty to disclose information of which they are aware and which is material to the evaluation of the patentability of the invention as required by the U.S. Patent and Trademark Office. Signing this form as inventor constitutes certification that all material information has been disclosed on this form or in supplemental sheets attached to this form and an acknowledgement that the duty to disclose such material information continues throughout the preparation and prosecution of any application for United States patent which may arise as a result of the submission of this form. As used herein, material information shall mean information such as details of prior art patents or publications which describe matters closely related to the invention as well as details off prior uses and sales of products embodying the invention of which the inventors are aware. Material information also includes technical changes to the invention which may be made to modify its performance for which are noted after submission of this form.

ACKNOWLEDGEMENT

I have read and understood the above description of the duty of disclosure required by the United States Patent and Trademark Office of individuals involved SUBSTANTIVELY in the preparation or prosecution of a United States Patent Application. I hereby affirm that to the best of my knowledge and belief, I have complied with that rule by disclosing as of the date of my signature hereto the following items (attach or identify all patents, publications, apparatus, search reports, data, or other documents).

PATENTS None

IF NONE WRITE "NONE"

PUBLICATIONS AND SEARCH REPORTS None

IF NONE WRITE "NONE"

OTHER INFORMATION OR DATA None

IF NONE WRITE "NONE"

INVENTOR SIGNATURE DATE

INVENTOR SIGNATURE DATE

INVENTOR SIGNATURE DATE

INVENTOR SIGNATURE DATE

Attached invention disclosure reviewed by me:

ATTORNEY SIGNATURE DATE

INVENTION DISCLOSURE

1.0 Title of Invention
Non-Contiguous Spread Spectrum Communications and Ranging

2.0 Inventors
Dennis McCrady

3.0 Description of the Operation of Other Similar Devices

A good example of other similar devices is presented in D. McCrady, et al.[1] This state-of-the-art position location and communication system provides accurate, reliable three-dimensional position location of a handheld or portable, spread spectrum communication device within milliseconds without interruption of voice or data communications. Using spread spectrum waveforms and processing techniques, the system is capable of determining position location to an accuracy of less than one meter and communications performance commensurate with the modulation and error correction coding that is employed in a severe multipath environment.

More particularly, the system employs a two-way, round-trip ranging message scheme in which the time of arrive of the ranging messages is accurately determined to yield accurate range estimates used to calculate the position of a mobile radio via trilateration. A master (the target) mobile radio transmits outbound ranging messages to plural reference radios. The reference radios respond by transmitting reply ranging messages that indicate the location of the reference radio and the message turn around time (i.e., the time between reception of the outbound ranging message and transmission of the reply ranging message). Upon reception of the reply ranging message, the master radio determines the signal propagation time, and hence range, by subtracting the turn around time and internal processing delays from the elapsed time between transmission of the outbound ranging message and the time of arrival of the reply message. In this manner, the individual radios do not need to be synchronized to a common time reference, thereby eliminating the need for highly accurate system clocks required in conventional time-synchronized systems. The brief ranging messages can be interleaved with voice and data messages in a non-intrusive manner to provide position location capabilities without disruption of voice and data communications.

To provide high accuracy range estimates, the time of arrival of the ranging messages are precisely estimated. By performing internal delay calibration, errors caused by difficult-to-predict internal transmitter and receiver delay variations can be minimized. The system uses state-of-the-art spread spectrum chipping rates and bandwidths to reduce multipath interference, taking advantage of existing hardware and software to carrying out a portion of the TOA estimation processing. Leading edge curve fitting is used to accurately locate the leading-edge of an acquisition sequence in the ranging message in order to further reduce the effect of multipath interference on TOA estimates. Frequency diversity is used to orthogonalize multipath interference with respect to the direct path

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[1] D. McCrady, L. Doyle, and H. Forstrom,"Method and Apparatus for Determining the Position of a Mobile Communication Device Using Low Accuracy Clocks," U.S. Patent Number 6453168, Issue Date September 17, 2002.

signal, wherein an optimal carrier frequency is used to estimate the TOA to minimize the impact of multipath interference.

Further, the system is self-healing. Unlike conventional systems that require communication with a set of fixed-location reference radios, this system can use a set of fixed and/or mobile reference radios. The set of radios relied upon to determine the location of a mobile communication device can vary over time depending on transmission conditions and the location of the mobile communication device. Any combination of fixed or mobile radios of known positions can be used as the reference radios for another mobile radio in the system, thereby providing adaptability under varying conditions.

The ranging and position location technique is useful in a wide variety of applications, including location and/or tracking of people and items such as: military personnel and equipment, emergency personnel and equipment, valuable items, vehicles, mobile telephones, children and prisoners.

4.0 Description of Some of the Shortcomings of the Above Mentioned Devices

The key shortcoming of the above mentioned device is the need for a wide, contiguous bandwidth to achieve the desired location accuracy. Location accuracy is inversely proportional to bandwidth and the square root of signal-to-noise ratio (SNR). A good strategy to improve location accuracy is to increase both bandwidth and SNR. Ideally, increasing bandwidth is the best way to improve accuracy because of the inverse square root relationship of improved accuracy with increasing SNR. But it is not always feasible to obtain a frequency allocation with enough bandwidth to support the desired location accuracy in one contiguous band.

In addition, a similar shortcoming applies to the communication of data. A wide, contiguous bandwidth is needed to support high rate data communications in a spread spectrum system. The ability to use non-contiguous frequency bands will ease the frequency allocation burden here as well.

5.0 General Description of How This Invention Overcomes the Aforementioned Difficulties

This invention overcomes the aforementioned difficulty by making it feasible to use non-contiguous frequency bands for spread spectrum time-of-arrival (TOA) ranging for location and data communications. As a result, it will be easier to obtain frequency allocations for improved ranging accuracy and higher data rate communications because increased bandwidth need not be contiguous.

In addition, the performance achievable using the (contiguous) bandwidth of the present state-of-the-art TOA ranging and communications system cited in reference 1 above, could be achieved using non-contiguous pieces of the spectrum.

6.0 Specific Description of the Operation of This Invention Mentioning All of the Components and Functions Thereof

The operation of this invention is shown in figure 1. Figure 1 is a block diagram of a spread spectrum modem that also performs TOA ranging and includes the non-contiguous spectrum selection (NCSS) function of the present invention. Without the NCSS function, this modem performs the functions cited in reference 1 above.

The NCSS function is based on a windowed Fast Fourier Transform (FFT), an excision function, and an inverse FFT. Each of these components will be described as they relate to the proposed invention and within the context of the spread spectrum modem.

At the top level, the signal from the baseband modulator is fed to the NCSS where it is transformed into the frequency domain by the length N, windowed FFT. The length N of the FFT is determined by the desired frequency resolution of the application being addressed, where:

Fr = frequency resolution = Fs/N, and

Fs = sampling rate.

Windowing is used to shape the frequency response of the FFT bins by providing lower sidelobes at the expense of widening the bandwidth of the bins. Any of the standard windows[2] can be used depending on the application and frequency allocation requirements.

The excision function involves removing the FFT bins at frequencies where the signal is to be excluded using techniques similar to those described in the open literature[3] for the interference excision application. For the present invention, the interfering signals are the portions of the communication or ranging signal spectra covered by one or more FFT bins that are removed because a frequency allocation cannot be secured.

After excision, a length = N inverse FFT used to transform the signal back into the time domain. The time domain signal then flows through the rest of the transmitter path as if it were a standard communication or TOA ranging signal. Note that the transmitted signal power can be amplified to compensate for the reduction in signal power due to the excision process.

The demodulator portion of Figure 1 is set up to process the spread spectrum signal at the chip rate generated by the modulator. The strength of the correlation function from the spread spectrum signal in the demodulator (and therefore the ability to perform TOA ranging and data communication) will be proportional to the amount of spectrum excised in the modulator. Reference 3 shows that the knee of the "percentage of FFT bins excised versus loss" curve is roughly (50%, 7.5dB) indicating a substantial range of operation for the technique proposed in this invention disclosure.

A brief example is presented for clarity where the bandwidth of the existing state-of-the-art system is doubled. The following assumptions are made with respect to Figure 1 for purposes of the example and hold for both communications and ranging.

- Spread spectrum chip rate = R_c = 64Mcps,
- Initial sample rate = F_{s1} = 128Msps,
- N = 128,
- Hanning window,
- Interpolated sample rate = F_s = 256Msps,
- Intermediate frequency = F_{IF} = 70MHz, and
- LPF at DAC output.

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[2] F. J. Harris, "On the Use of Windows for Harmonic Analysis with the Discrete Fourier Transform," Proceedings of the IEEE, Vol. 66, No. 1, January 1978.

[3] J. A. Young, "Analysis of DFT-Based Frequency Excision Algorithms for Direct-Sequence Spread-Spectrum Communications," IEEE Transactions on Communications, Vol. 46, No. 8, August 1998.

With these assumptions, the frequency resolution at the FFT output is:

$F_r = 1.5 \times (128\text{Msps}/128) = 1.5\text{MHz}$.

The transmitted signal has a –40dB bandwidth of 64MHz. Segments of the spectrum that are 1.5MHz wide can be eliminated from the signal in order to reduce the bandwidth of the frequency allocation request to reach an acceptable compromise with the government frequency allocation authority.

7.0 List All Possible Applications

- Location of military personnel/resources within a building where GPS is not available
- Augmentation/improvement of GPS location of military personnel during external exercises
- Location of non-military personnel/resources within a building or outside such as:
  - Firefighters
  - Doctors/nurses/medical equipment
  - Police during tactical operations
  - Prisoners
- Location of cell phone users for emergency purposes
- High value resource location.

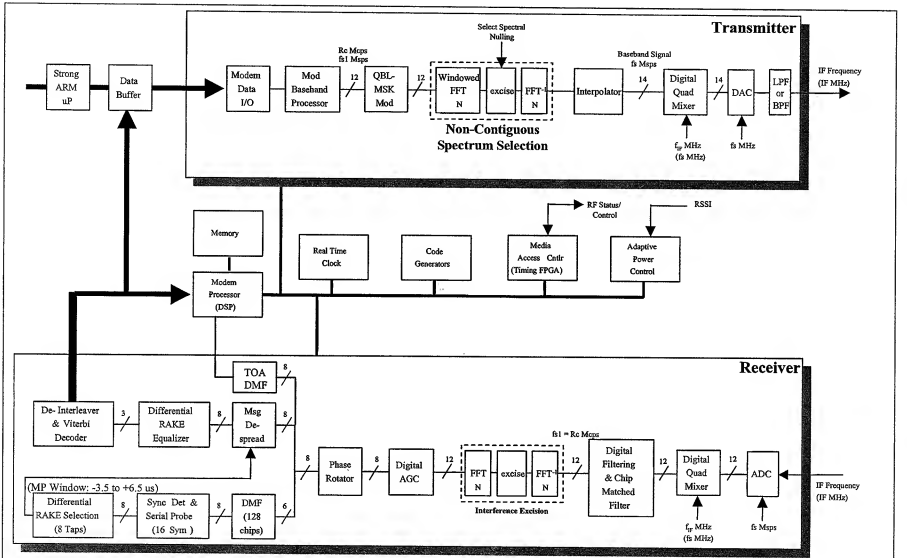

Figure 1: Non-Contiguous Spread Spectrum Modem With TOA Ranging